

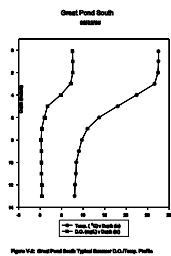
CHAPTER V WATER QUALITY

A. TEMPERATURE AND DISSOLVED OXYGEN

Great Pond has a typical thermal stratification cycle for a north temperate dimictic lake. Stratification developed by the middle of May and remained until late October, with the depth of the thermocline becoming characteristically deeper as the summer progressed. During June and July, the thermocline existed from 3.0 to 8.0 meters at the North Station and the South Station. During late August, the thermocline depths ranged from 4.0 to 9.0 meters at the North Station and from 5.0 to 10.0 meters at the South Station. By early November both the North and the South Station had mixed, with less than a two degree temperature difference between the surface and the bottom (13.0 m). Great Pond had isothermal conditions during spring and fall overturn, and was typically inversely stratified during ice-cover periods. Typical summer dissolved oxygen and temperature profiles for the North and South Stations at Great Pond appear in Figures V-1 and V-2 respectively. Additional profiles and raw data are compiled in Appendix V-1.

The North Station of Great Pond exhibited anoxic conditions in the hypolimnion from early June through the fall turnover. A zone of anoxia ranged from 10.0 meters to the bottom (13.0 m) by early July and expanded steadily as the summer progressed. By late August and into early October, anoxic conditions existed from 6.0 meters to the bottom of the lake. The South Station of Great Pond exhibited similar conditions of anoxia however, conditions here were slightly different since this basin is more open to wind and wave action. Anoxia did not exist in the South Station until late June, and more evidence of turnover was observed in the south basin in the mid-October profile. A significant zone of anoxia did not become established until late July, spanning from 11.0 meters to the bottom (13.0 m). By late August the anoxic zone reached a maximum of 5.0 meters to the bottom of the lake.

Several factors contribute to hypolimnetic anoxia, including strong thermal stratification



and various biological and chemical interactions that occur in the hypolimnion. Significant biological utilizers of dissolved oxygen include the population of decomposing bacteria which break down all organic material that drifts to the pond's bottom. This process utilizes available oxygen and liberates carbon dioxide.

Hypolimnetic anoxia is significant in Great Pond because it allows for the release of phosphorus from bottom sediments into the overlying water layer (internal loading). This liberated phosphorus, a limiting nutrient for plant life, may cause seasonal planktonic blooms in the pond. Internal loading was evident at both stations during the late summer, but was most acute in the North Station. An in-depth discussion of internal loading in Great Pond can be found in the Total Phosphorus section of this chapter.

B. PH AND ACID NEUTRALIZATION CAPACITY (ANC)

The hydrogen ion concentration, or pH, is defined as the negative base 10 logarithm of the hydrogen ion activity in moles per liter. The pH scale ranges from 0-14 with 7 being a neutral value. "Pure" water has a pH of 7 which means it contains 1×10^{-7} moles per liter of hydrogen ions. The pH scale is logarithmic, therefore each unit change is a tenfold change. A pH of 5 is ten times more acidic than a pH of 6. "Natural" rain water at equilibrium with the atmosphere has a pH of 5.6. Most New Hampshire lakes are slightly acidic, with pH values between 6 and 7. When the pH value falls between 6 and 5.5 the waters are considered endangered. Lakes with pH values from 5.4 to 5 are considered in the critical range, and below this point lakes are considered acidified.

One of the most important reactions occurring in water, and one which affects pH, is that of dissolved carbon dioxide, represented by the following equilibrium equation:

$$\text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3 \rightleftharpoons \text{H}^+ + \text{HCO}_3^- \rightleftharpoons 2\text{H}^+ + \text{CO}_3^{2-}$$

When phytoplankton consume CO_2 during daylight hours in photosynthesis, the equilibrium shifts toward the left. This results in fewer free H^+ ions, causing a decrease in H^+ ion concentration and thus an increase in pH. It is, therefore, not uncommon to find high pH values associated with an algal bloom.

The acid neutralizing capacity (ANC) of water is the capacity of water to accept protons, or, in other words, to neutralize hydrogen ions. It is primarily a measure of the concentration of carbonates, bicarbonates, and hydroxides in the water. New Hampshire lake waters are generally low in ANC (ranging from 2 to 20 mg/L as CaCO_3). This is due in part to the state's granitic

bedrock which contains few of these compounds. As a result, New Hampshire lakes have a poor buffering capacity, and thus are more susceptible to some ionic pollutants than higher ANC lakes.

1. Great Pond Tributary pH

Great Pond tributaries had pH values ranging from a low of 4.13 units in Lincoln tributary to a high of 6.89 units at Thayer Inlet. The highest true mean pH for the study year was 6.46 units at Thayer Inlet. The lowest true mean pH for the study year occurred in Lincoln tributary and was 4.29 units. The minimum pH values recorded in Ball Road and Lincoln tributary reflect sub-watersheds that are dominated by wetland complexes which contribute organically derived acids such as humic and tannic acids (that reduce the pH of receiving waters).

As Table V-1 illustrates, the seasonal distribution of pH values indicates that for the majority of the tributaries maximum values occurred in the summer. The range of true mean values during the summer was from 6.09 to 6.82 units. The summer is the time of maximum biological productivity within the watershed and this will cause elevated pH levels in surface waters. The only exception to this distribution was Kelley Brook which had its maximum true mean pH value during the spring.

Minimum pH values also had seasonal distribution patterns at Great Pond. All of the tributaries had seasonal true mean pH minima during the winter, with values ranging from 4.25 to 6.09 units. All of the tributaries in the Great Pond watershed contain substantial wetland complexes. During the winter season, biological productivity decreases greatly, and thus there is a greater amount of free H^+ ions, and a resultant decrease in pH. Also, decomposition of organic matter in the wetland will generate CO_2 , shifting the equilibrium equation to the right which produces more free H^+ ions.

Table V-1
True Mean Study Period and Seasonal pH for Great Pond Tributaries
November 1994 through November 1995

Station # & Site Name	Study Period		Winter	Spring	Summer	Fall
	Mean	Median				
1. Thayer Inlet	6.46	6.41	6.09	6.69	6.82	6.11
2. Bartlett Beach Inlet (seasonal)	*6.98	*6.98	-	-	-	-

3. Ball Road Inlet	5.57	5.50	5.23	5.62	6.09	5.36
4. Camp Lincoln (seasonal)	4.34	4.38	4.25	4.41	-	-
5. Halfmoon Outlet	5.88	5.84	5.70	6.10	-	5.84
6. Kelley Brook	6.54	6.5	6.04	6.54	6.48	6.25
7. Outlet	6.71	6.72	6.06	6.95	6.78	6.78

* only one data point for this tributary.

The pH values of Great Pond tributaries were for the most part, within satisfactory levels. Five out of seven tributaries monitored had study year true mean pH values near or above 6.0 units. The two tributaries with true means significantly below 6.0 pH units were Ball Road and Lincoln which had study year means of 5.57 and 4.34 respectively. The study year means for these two brooks place them in the endangered and critical categories. However, the sub-watersheds of each tributary are dominated by wetlands and values reflect the impact of the associated biological processes occurring within these areas.

2. Great Pond Tributary Acid Neutralizing Capacity

The mean ANC values for the Great Pond tributaries during the study period fell between a minimum of -1.90 mg/L as CaCO₃ in Lincoln Brook and a maximum value of 11.34 mg/L in Thayer Inlet (Table V-2). A single value of 17.60 mg/L as CaCO₃ was found at Bartlett Beach Inlet, but because of a dry year it is the only data point for that tributary. The wide range of ANC values observed in the tributaries during the study period reflects the diverse environmental composition and underlying geology of the Great Pond watershed. Appendix V-4 depicts the tributary ANC range and mean values for the study period.

Table V-2
Mean Study Period and Seasonal Acid Neutralizing Capacity (mg/L as CaCO₃)
for Great Pond Tributaries
November 1994 through November 1995

Station # & Site Name	Study Period		Winter	Spring	Summer	Fall
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	Mean	Median				
1. Thayer Inlet	11.34	11.80	-	10.40	17.00	8.50
2. Bartlett Beach Inlet (seasonal)	*17.60	*17.60	-	17.60	-	-
3. Ball Road Inlet	3.97	2.10	-	4.20	10.65	1.74
4. Camp Lincoln (seasonal)	-1.90	-1.60	-3.10	-1.50	-	-
5. Halfmoon Outlet	4.45	4.65	-	4.20	-	*5.84
6. Kelley Brook	8.31	7.75	-	5.30	12.85	8.3
7. Outlet	7.85	8.30	-	6.30	8.60	9.45

* only one data point for this tributary.

3. Great Pond In-lake pH

Biological activities can influence the pH of the water. Planktonic photosynthesis removes carbon dioxide from the lake, causing the pH to rise. For this reason the photic zone tends to have higher pH values than the underlying layers, and the highest values are recorded during the summer when phytoplankton populations are at their maximum levels. Spring and fall overturn values are nearly uniform throughout the water column.

In general, pH values from both in-lake sites at Great Pond followed this trend (Table V-3 and Table V-4). During the summer months the true mean pH was highest in the epilimnion where photosynthesis was the greatest, and decreased progressively toward the bottom. The remainder of the year showed similar trends although the difference in values from the surface to bottom was less dramatic.

All of the pH values observed at the in-lake stations close to or above the New Hampshire state mean of 6.5 and fell within the satisfactory criteria for pH ranges.

4. Great Pond In-lake Acid Neutralizing Capacity (ANC)

In contrast to pH, ANC values tend to be higher at the bottom of a lake. This is caused by the release of buffering materials from the lake sediments to the overlying waters. In most lakes, this trend can be seen during the summer season and to a lesser extent in the fall. As Tables V-3 and V-4 illustrate, in Great Pond the maximum ANC values for both stations occurred during the fall. The maximum mean ANC value for the North Station was 13.7 mg/L, and 15.0 mg/L for

the South Station. ANC values generated during the study year at Great Pond are above the New Hampshire lakes and ponds mean of 6.5 mg/L yet are still considered to be somewhat vulnerable to acid inputs.

Table V-3
Great Pond (South Station) In-lake Seasonal Chemistry Data
November 1994 through November 1995

WINTER	UPPER		LOWER	
	mean	median	mean	median
pH (units)	6.50	6.47	6.45	6.53
ANC (mg/L)	7.53	7.30	7.57	7.10
Conductivity (µmhos/cm)	118.80	117.10	119.67	120.70
TP (µg/L)	14.70	14.00	12.70	12.00
NO ₃ -N (mg/L)	0.09	0.09	0.11	0.11
TKN (mg/L)	0.33	0.33	0.30	0.30
Color (units)	46	50	48	55
Cl- (mg/L)	26	27	27	27
SO ₄ (mg/L)	7	7	8	8
SPRING	UPPER		LOWER	
	mean	median	mean	median
pH (units)	6.64	6.72	6.33	6.31
ANC (mg/L)	6.60	7.15	6.88	7.55
Conductivity (µmhos/cm)	117.00	116.00	117.60	115.20
TP (µg/L)	12.00	12.00	12.50	12.50
NO ₃ -N (mg/L)	0.06	0.05	0.15	0.10

TKN (mg/L)	0.26	0.26	0.15	0.25
Color (units)	42	42	48	47
Cl- (mg/L)	27	27	28	28
SO ₄ (mg/L)	7	7	7	7

Table V-3 (Cont.)
Great Pond (South Station) In-lake Seasonal Chemistry Data
November 1994 through November 1995

SUMMER	EPILIM NION		METALI MNION		HYPOLI MNION	
	mean	median	mean	median	mean	median
pH (units)	6.91	6.88	6.49	6.48	6.30	6.40
ANC (mg/L)	8.61	8.25	8.34	8.40	8.25	8.70
Conductivity (µmhos/cm)	125.20	125.50	122.89	123.50	123.90	122.40
TP (µg/L)	8.00	8.50	11.40	11.00	18.60	17.50
Turbidity (NTU's)	-	-	-	-	-	-
NO ₃ -N (mg/L)	-	-	-	-	-	-
Color (units)	41	40	43	41	100	105
Cl- (mg/L)	-	-	-	-	-	-
SO ₄ (mg/L)	-	-	-	-	-	-
FALL	UPPER		LOWER			
	mean	median	mean	median		
pH (units)	6.77	6.84	6.60	6.44		
ANC (mg/L)	8.84	8.80	15.00	15.00		
Conductivity (µmhos/cm)	131.80	132.50	134.25	140.00		
TP (µg/L)	10.40	11.00	13.40	12.00		
TKN (mg/L)	-	-	-	-		
NO ₃ -N (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05		
Color (units)	-	-	-	-		

Cl- (mg/L)	29	29	28	28
SO ₄ (mg/L)	7	7	7	7

Table V-4
Great Pond (North Station) In-lake Seasonal Chemistry Data
November 1994 through November 1995

WINTER	UPPER		LOWER	
	mean	median	mean	median
pH (units)	6.51	6.50	6.48	6.50
ANC (mg/L)	7.57	7.50	8.30	8.70
Conductivity (µmhos/cm)	118.90	118.60	122.80	126.10
TP (µg/L)	11.30	11.00	11.30	11.00
NO ₃ -N (mg/L)	0.11	0.11	0.11	0.11
TKN (mg/L)	0.34	0.38	0.31	0.35
Color (units)	48	55	49	55
Cl- (mg/L)	27	27	28	28
SO ₄ (mg/L)	8	8	8	8
SPRING	UPPER		LOWER	
	mean	median	mean	median
pH (units)	6.72	6.71	6.33	6.27
ANC (mg/L)	7.15	7.00	7.08	7.60
Conductivity (µmhos/cm)	118.10	117.20	120.80	115.30
TP (µg/L)	13.80	13.00	24.00	24.00
NO ₃ -N (mg/L)	0.09	0.10	0.09	0.10
TKN (mg/L)	0.23	0.23	0.24	0.24
Color (units)	42	42	46	46
Cl- (mg/L)	28	28	28	29
SO ₄ (mg/L)	7	7	7	8

Table V-4 (Cont.)
Great Pond (North Station) In-lake Seasonal Chemistry Data
November 1994 through November 1995

SUMMER	EPILIM NION		METALI MNION		HYPOLI MNION	
	mean	median	mean	median	mean	median
pH (units)	6.95	6.95	6.54	6.52	6.36	6.32
ANC (mg/L)	8.95	8.85	7.45	8.35	8.99	8.20
Conductivity (µmhos/cm)	125.00	124.50	121.20	120.50	108.33	117.70
TP (µg/L)	10.20	9.50	10.00	10.00	26.50	24.00
Turbidity (NTU's)	-	-	-	-	-	-
NO ₃ -N (mg/L)	-	-	-	-	-	-
Color (units)	41	40	42	42	93	95
Cl- (mg/L)	-	-	-	-	-	-
SO ₄ (mg/L)	-	-	-	-	-	-
FALL	UPPER		LOWER			
	mean	median	mean	median		
pH (units)	6.79	6.68	6.63	6.58		
ANC (mg/L)	9.02	9.40	13.70	13.70		
Conductivity (µmhos/cm)	131.50	130.80	130.60	129.70		
TP (µg/L)	11.80	11.00	40.00	41.00		
TKN (mg/L)	0.23	0.23	0.40	0.40		
NO ₃ -N (mg/L)	<0.05	<0.05	<0.05	<0.05		
Color (units)	41	42	99	140		
Cl- (mg/L)	27	27	27	27		
SO ₄ (mg/L)	7	7	7	7		

C. SPECIFIC CONDUCTANCE

Specific conductance (conductivity) is a measure of the capacity of water to conduct an electrical current. This ability to conduct electricity is determined primarily by the concentration of charged ionic particles present in the waters. The soft waters of New Hampshire generally have a low conductance relative to highly mineralized waters found in some parts of the country. The conductance of water is related to the presence of dissolved solids, and thus is usually higher in sewage, for example, than in natural waters. The mean conductivity value for summer surface waters for all New Hampshire lakes is 56.8 $\mu\text{mhos/cm}$ with a median of 37.2 $\mu\text{mhos/cm}$.

1. Great Pond Tributary Specific Conductance

Mean tributary conductivity values for the study period ranged from a low of 67.1 $\mu\text{mhos/cm}$ in Lincoln Brook to a maximum of 134.0 $\mu\text{mhos/cm}$ in Thayer Brook. Mean and median conductivity values were high in comparison to other tributaries sampled in the state, but similar to those sampled around urban lakes in the region (Connor et al 1985). Urban runoff may contain road salt, fertilizers, septic system leachate, and other pollutants which may lead to elevated conductivity values. Cultural impact is felt by all of Great Pond's tributaries to various degrees.

2. Great Pond Specific Conductance

Conductivity measurements for the study year at the North and South Stations of Great Pond indicate epilimnetic values well above the New Hampshire average of 56.8 $\mu\text{mhos/cm}$ (Appendix V-5). Values at both lake stations were very similar throughout the water column for the duration of the study year. Mean seasonal conductivity values ranged from a minimum of 117.00 $\mu\text{mhos/cm}$ in the upper layer of the South Station in the spring to a maximum value of 134.25 $\mu\text{mhos/cm}$ during the fall in the lower layer of the South Station. This value may be due to the sediment release of ionic particles into the overlying waters. Lake data is presented in Tables V-3 and V-4.

Table V-5
Mean Study Period and Seasonal Specific Conductance ($\mu\text{mhos/cm}$)
for Great Pond Tributaries
November 1994 through November 1995

Station # & Site Name	Study Period		Winter	Spring	Summer	Fall
	Mean	Median				

1. Thayer Inlet	134.0	134.3	123.1	127.5	147.2	131.8
2. Bartlett Beach Inlet (seasonal)	*467	*467	-	-	-	-
3. Ball Road Inlet	78.4	61.3	61.2	55.2	96.7	97.3
4. Camp Lincoln (seasonal)	67.1	68.9	58.4	70.8	-	-
5. Halfmoon Outlet	119.3	120.4	124.9	115.9	-	110.7
6. Kelley Brook	119.8	117.7	109.1	105.9	127.9	133.5
7. Outlet	128.1	132.3	118.3	119.5	136.5	133.3

* only one data point for this tributary.

D. CHLORIDE

Chloride is one of the major anions measured in water. Natural sources of chloride include the weathering of igneous and sedimentary rocks and rainfall (occurring as cyclic chlorides), while artificial sources include many point and nonpoint sources such as road salt runoff and faulty septic systems. The median summer epilimnetic chloride level for New Hampshire lakes is 4 mg/L.

Due to budget cuts by the Environmental Protection Agency during the Great Pond study, some laboratory analyses had to be curtailed; because of this, there is significantly less chloride data than in past studies done by NHDES.

1. Great Pond Tributary Chloride

Observed Chloride levels for the tributaries ranged from 13 mg/L in Ball Road Inlet to 32 mg/L in Kelley Brook. All chloride levels observed are above the cultural impact level of 7.0 mg/L. Most sample sites are near state highways or major town roads, so it is likely that road salt runoff is the major contributor to high Chloride levels. The Halfmoon Outlet chloride result of 27.0 mg/L corresponds well to lake survey data of Halfmoon Pond from 1995, where 24.0 mg/L was observed in the epilimnion. This elevated level is likely due to both road salt runoff from Great Pond Park and septic system leachate from development around the lake.

Table V-6

Great Pond Diagnostic/Feasibility Study

Great Pond Tributary Chloride Data

Station # & Site Name	10/18/94
1. Thayer Inlet	29
2. Bartlett Beach Inlet (seasonal)	-
3. Ball Road Inlet	13
4. Camp Lincoln (seasonal)	-
5. Halfmoon Outlet	27
6. Kelley Brook	32
7. Outlet	30

2. Great Pond In-Lake Chloride

Median study year chloride levels for Great Pond ranged from a minimum of 28 mg/L in the lower layer of South Station to a minimum of 27 mg/L in the upper layer of both lake stations (Tables V-3 and V-4). Chloride values at the North and South Stations were relatively uniform throughout the study year, and were at least five times the state median. This indicates significant influence from cultural impacts such as leach field drainage and road salt runoff. These results however, are typical of results found in other lakes in southern New Hampshire.

E. SULFATE

Sulfates are utilized by all living organisms for protein synthesis. Sulfates are usually abundant in aquatic systems, entering through erosion of rocks, fertilizer runoff and through atmospheric transport by precipitation and dry fall. The median summer epilimnetic sulfate concentration for New Hampshire lakes is 4 mg/L.

Median study year sulfate concentrations at Great Pond ranged from a minimum of 7 mg/L in the upper layer of both stations to a maximum of 8 mg/L in the lower layer of both stations (Tables V-3 and V-4).

F. APPARENT COLOR

Apparent color is the visual determination of the darkness of the water. Color in the water may result from substances in solution (iron, manganese and leachate from decaying organic matter) and suspended matter (plankton and silt). Tea colored waters [color values greater than 40 chloroplatinate units (CPU)] are generally naturally colored from decaying organic matter. For this reason, drainage from wetlands tend to have high color values. The median summer eplimnetic color value for New Hampshire lakes is 28 CPU. Raw color data is presented in Appendix V-3.

1. Great Pond Tributary Apparent Color

As Table V-7 indicates, median color values for the Great Pond tributaries during the study year ranged from a minimum of 41CPU at the Outlet to a maximum of 134 CPU at Camp Lincoln Brook. Usually tributaries experienced seasonal maximum color values in the summer months when processes of decomposition within the watershed are peaking. The dry summer experienced during the study year both limited the quantity of summer data and skewed what little data that was collected. Two tributaries that flowed more reliably during the study year, Kelley Brook and Thayer Brook, showed the normal trend. The rest of the inflowing tributaries either had no summer data, or the data was skewed due to a very limited data set.

Table V-7
Great Pond Tributaries Mean Study Period and Seasonal Apparent Color (CPU)
November 1994 through November 1995

Station # & Site Name	Study Period		Winter		Summer	Fall
	Mean	Median				
1. Thayer Inlet	70	63	60	62	75	75
2. Bartlett Beach Inlet (seasonal)	*55	*55	-	-	-	-
3. Ball Road Inlet	121	135	110	127	100	130
4. Camp Lincoln (seasonal)	134	140	>140	130	-	-
5. Halfmoon Outlet	82	85	85	75	-	100
6. Kelley Brook	78	75	85	60	98	75
7. Outlet	41	41	55	44	41	31

* only one data point for this tributary.

2. Great Pond Apparent Color

Tables V-3 and V-4 present apparent color data for the North and South Stations of Great Pond. Apparent color values during the stratified season in the North and South Station displayed a wide range from epilimnetic waters to the hypolimnion. Color values during this period ranged from 40 CPU in the epilimnion to 105 CPU in the hypolimnion. Color usually increases in the water column towards the hypolimnion due to sediment release of materials and decomposition in the benthic area.

G. TOTAL PHOSPHORUS

Phosphorus is an essential element for plant growth, and is the limiting nutrient that regulates the productivity of New Hampshire lakes. Much effort in controlling the eutrophication of lakes has been directed toward controlling the phosphorus load to a lake. Unacceptable levels of phosphorus are often associated with human activities, and it appears that, in most cases, the removal or reduction of phosphorus from nonpoint sources will curtail algal productivity in lakes.

Total phosphorus was measured in this study by the persulfate digestion procedure, and includes all phosphorus forms in water. Total phosphorus is composed primarily of organic phosphorus, which includes phosphorus present in algal cells, and inorganic orthophosphate. The total phosphorus range for the summer epilimnetic values of lakes sampled in New Hampshire is between <1 and 121 $\mu\text{g/L}$, with a median value of 12 $\mu\text{g/L}$.

The major purpose of this study was to determine significant phosphorus sources to Great Pond and to propose remediation. Sources of phosphorus include: 1) precipitation 2) groundwater 3) surface runoff 4) septic leachate 5) tributary flux and 6) internal phosphorus cycling.

1. Great Pond Tributary Total Phosphorus

The highest mean total phosphorus concentration of the Great Pond inflowing tributaries was observed in Bartlett Beach Inlet (49 $\mu\text{g/L}$) while the lowest mean was observed at Halfmoon Outlet (17 $\mu\text{g/L}$). Ball Road Inlet experienced a maximum phosphorus concentration of 615 $\mu\text{g/L}$ and a minimum of 8 $\mu\text{g/L}$ during the study year, while Kelley Brook experienced a maximum of

only 81 µg/L and a minimum of 7 µg/L. It is important to note that the 615 µg/L reading at Ball Road Inlet was observed in mid-July just before the stream went dry for the summer, and the flow at the time was very low. Ball Road Inlet is fed by a large wetland complex, accounting for the much wider variability in phosphorus levels when compared to Kelley Brook which features fewer wetlands in its watershed.

The seasonal distribution of phosphorus shows that all five inflowing tributaries had maximum seasonal mean concentrations during the summer months (Table V-8). The majority of these tributaries have subwatersheds characterized by wetlands, beaver impoundments and ponds (Appendix III-2).

The fact that all tributaries within the Great Pond watershed experienced maximum seasonal phosphorus concentrations during the summer months, contradicts the expected function of wetlands to act as a filter during the growing season.

In fact, a review of the literature dealing with phosphorus dynamics in wetlands reveals a strong variability of results. Some researchers believe wetlands are sources of phosphorus, others believe they are sinks while some contend that they can be seasonal sources and sinks.

Richardson (1988) has examined the ecological value of wetlands in terms of the ability to filter materials, transform nutrients, and function as sources or sinks. Macrophytes are mainly responsible for the recycling of phosphorus through root uptake from the soil; rather than removing phosphorus from the water itself. Plants may therefore be a source of phosphorus to the water during their decomposition. Richardson concludes that wetlands are incorrectly depicted as sinks when, in fact, they should be recognized as transformers. Wetlands with organic soils, similar to the Great Pond watershed wetlands do not retain phosphorus as efficiently as forested systems and are often a source of nutrients rather than a sink for them (Connor and Martin 1989b).

The high phosphorus values contributed by the Great Pond tributaries during the summer months emulated the four year study conducted on Chadwick Meadows in North Sutton, New Hampshire (Connor and Martin 1989b). This study found that the Chadwick Meadows wetland complex was a significant source of total phosphorus within the Kezar Lake watershed, providing an average increased phosphorus loading of 4.79 Kg on a monthly basis over the study period. Further, an average of 18.5 KgP was contributed during the summer months of June, July, and August.

Table V-8
Great Pond Tributaries Mean Study Period and Seasonal Total Phosphorus ($\mu\text{g/L}$),
November 1994 through November 1995

Station # & Site Name	Study Period		Winter	Spring	Summer	Fall
	Mean	Median				
1. Thayer Inlet	32	28	26	25	42	30
2. Bartlett Beach Inlet (seasonal)	49	41	-	-	-	-
3. Ball Road Inlet	46	24	12	22	164	23
4. Camp Lincoln (seasonal)	26	15	10	29	42	39
5. Halfmoon Outlet	17	15	14	11	32	23
6. Kelley Brook	20	16	12	18	26	21
7. Outlet	10	10	12	11	9	9

2. Great Pond Total Phosphorus

Total phosphorus concentrations in the North Station of Great Pond exhibited relatively uniform values during the spring and winter months. Mean total phosphorus concentrations during these seasons ranged from 8 $\mu\text{g/L}$ in the epilimnion during the spring to a maximum of 15 $\mu\text{g/L}$ in the lower layer during the spring.

The widest range of mean phosphorus concentration was observed during the late summer and fall months with a minimum value of 6 $\mu\text{g/L}$ in the upper layer to 84 $\mu\text{g/L}$ in the lower layer. This reflects the strong stratification that develops during the summer months and the subsequent development of anoxic conditions in the hypolimnion. The high phosphorus concentrations during the fall are an indication of internal phosphorus loading from the sediment when anoxic conditions exist. Fall mixing at the North Station does not occur until mid to late October due to the depth and severity of stratification. Phosphorus levels become uniform throughout the water column following fall turnover.

Total phosphorus concentrations observed at the South Station were relatively homogeneous throughout the water column during the study year. Mean concentrations ranged from 8 $\mu\text{g/L}$ in the lower layer during the fall to 19 $\mu\text{g/L}$ in the lower layer during the summer.

The elevated concentrations during the summer indicate internal phosphorus loading as a result of anoxic conditions that develop at the sediment/water interface. It is interesting to note that while the South Station stratified and the hypolimnion became anoxic like the North Station, it did not exhibit internal phosphorus loading to the same degree as the North Station. A close look at the dissolved oxygen profiles at both stations reveals that the North Station had a lower level of oxygen than the South Station. The mean dissolved oxygen % saturation level for August and September was 3.9% in the North Station and 5.0% in the South Station at the sediment/water interface.

In general, epilimnetic total phosphorus concentrations at both lake stations were very close to the New Hampshire state median of 12.0 µg/L (Appendix V-5). Tables V-3 and V-4 present the seasonal total phosphorus data for the North and South Stations respectively. Appendix V-3 presents the raw total phosphorus data for the study year.

H. NITROGEN

A component of proteins, nitrogen is a major nutrient essential for plant growth. Nitrogen may be present in water as dissolved nitrogen gas, organic nitrogen compounds and inorganic nitrogen compounds including ammonia, nitrite and nitrate.

With the exception of some bluegreen algae that utilize atmospheric nitrogen (N₂), most algae use inorganic nitrogen. Of the forms listed above, ammonia is the preferred source because it is already at the reduction level of organic nitrogen, and thus is assimilated into protein at a minimal energy cost. Ammonia nitrogen is gradually oxidized by nitrifying bacteria into nitrite and nitrate.

Sources of nitrogen include precipitation, nitrogen fixation in the water and sediments by bacteria and certain bluegreen algae, and inputs from surface and groundwater drainage. Natural sources of the most commonly used form, ammonia, include excretory products from ammonifying bacteria, zooplankton and the urea of higher animals such as found in raw sewage (Martin and Goff, 1972; Keeney, 1972; Brezonik *et al.* 1973).

Inorganic nitrate nitrogen, and organic Total Kjeldahl Nitrogen (TKN) were the nitrogen forms measured at Great Pond. Based on data collected from 671 waterbodies, the median summer epilimnetic value for nitrate nitrogen in New Hampshire lakes and ponds is <0.05 mg/L, and the median TKN is 0.3 mg/L.

Due to budget cuts by the Environmental Protection Agency during the Great Pond study some laboratory analyses had to be curtailed; because of this, there is significantly less Nitrogen data than in past studies done by NHDES.

2. Great Pond Tributary Nitrate & TKN

One sampling for nitrate was conducted on the tributaries during the study year. The results are presented in Table V-9. All results of samples taken on October 18, 1994 were below the detection limit of the method used by the NHDES chemistry laboratory.

TKN data for Great Pond tributaries is summarized in Table V-10. Most inflowing tributaries are above the New Hampshire median of 0.3 mg/L, this likely due to organic nitrogen coming from the wetlands in the watershed. Ball Road Inlet, the tributary with the highest level of TKN (0.64 mg/L) has large wetland complexes that feed it.

Table V-9
Great Pond Tributary Nitrate (mg/L) Data

Station # & Site Name	10/18/94
1. Thayer Inlet	< 0.05
2. Bartlett Beach Inlet (seasonal)	-
3. Ball Road Inlet	< 0.05
4. Camp Lincoln (seasonal)	-
5. Halfmoon Outlet	< 0.05
6. Kelley Brook	< 0.05
7. Outlet	< 0.05

Table V-10
Great Pond Tributary TKN (mg/L) Data
November 1994 through November 1995

Station # & Site Name	Study Period	
	Mean	Median
1. Thayer Inlet	0..48	0.50
2. Bartlett Beach Inlet (seasonal)	0.18	0.17
3. Ball Road Inlet	0..64	0..68
4. Camp Lincoln (seasonal)	0.44	0.34
5. Halfmoon Outlet	0.41	0.39
6. Kelley Brook	0.45	0.44
7. Outlet	0.29	0.29

2. Great Pond In-Lake Nitrate

Nitrate concentrations for the sample year at the North Station of Great Pond exhibited minimal seasonal variations in (Tables V-3 and V-4). Values ranged from a minimum of <0.05 mg/L during the summer to a maximum of 0.11 mg/L in the lower water layer during the winter. Nitrate concentrations did not significantly differ with water column depth and remained well within, or only slightly above the New Hampshire median.

The available TKN data was at or below the New Hampshire median (Tables V-3 and V-4), however an incomplete data set made seasonal comparisons impossible.